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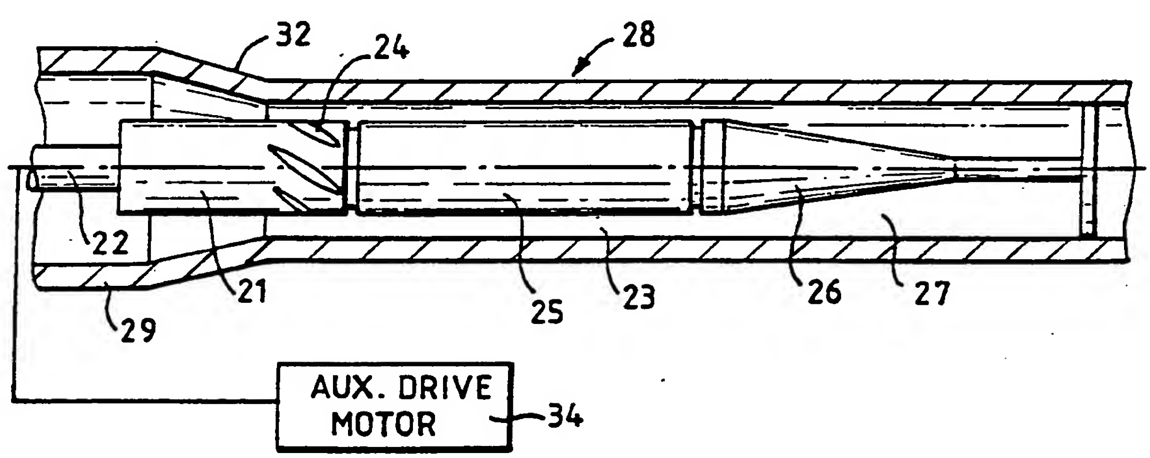

(57) Abstract

A pump comprises a housing (28) with a hollow rotor (21) within the housing and means (22) for feeding driving fluid to the rotor interior. The rotor (21) is provided with nozzles (24) forming jets of driving fluid supplied from its interior directed partly axially and partly tangentially into the chamber between the housing and the rotor. This causes the rotor to rotate as the driving fluid passes from the interior of the rotor to the chamber between the housing and the exterior of the rotor. A stator (25) is provided downstream of the rotor forming with the housing an annular chamber (23) of uniform section along its length into which the fluid between the housing and the rotor exterior flows. This flow of driving fluid can entrain secondary media (15) supplied to the passage between the exterior of the rotor and the housing, so that the two media are mixed and the secondary medium is pumped by the action of the driving fluid. Additional rotative force (33, 34) can be applied to the rotor if that generated by the driving fluid itself is not sufficient. Downstream of the annular chamber (23), a stator portion (26) of converging section may be provided.

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PUMP

In an axial flow pump, a rotor rotates within a housing and the fluid material to be pumped passes along a passage between the rotor and housing. In the conventional rotodynamic pump, blades extend radially from the rotor, and possibly the housing, into the passage and are arranged so that their reaction on the fluid material in the passage, as the rotor rotates, causes the fluid material to be driven axially through the passage.

In a jet pump, high pressure driving fluid is discharged from a nozzle at high velocity in the form of a turbulent jet into a driven fluid thereby dropping the pressure in the jet to below that of the driven fluid so that the jet entrains the driven fluid in a mixing chamber of constant cross sectional area where mixing takes place. The pressure of the liquid is then increased in a diffuser by slowing down the velocity of the mixture.

GB-A-0860073 suggests that the conventional rotor of an axial flow pump can be replaced by a hollow spinning impeller formed with nozzles on its periphery, the nozzles being inclined so that fluid expelled from the interior of the impeller into the passage creates a "pseudo blade" which reacts on the material in the passage as described above. The jets of fluid discharged from the impeller at an angle to the axis of rotation causes the rotation of the impeller and creates the pseudo blades which react upon the material. The fluids expelled through the nozzles combine with the material in the passage and transfer energy to them. In this arrangement there are no physical blades.

The present invention improves on this type of pump in one aspect by providing a mixing volume immediately

downstream of the impeller, the volume being of constant section and bounded on the outside by the housing and the inside by a non-rotating body, preferably of the same section as the spinning impeller. The pump may include a further body portion downstream of the mixing section, the further body portion including a central diffuser of decreasing cross-section.

In addition or as an alternative to the improvements mentioned in the preceding paragraph, the spinning impeller may be provided with physical blades upstream of the nozzles, which blades are arranged to swirl the material in the passage between the spinning impeller and the stator before it reaches the nozzles of the spinning impeller. The passage for the pumped material may be of greater cross-section in the region of the physical blades than adjacent the nozzles and, where present, the mixing section.

Examples of the prior art and of the invention will now be described with reference to the accompanying drawings, in which

Figure 1 shows a prior art impeller,

Figure 2 shows an impeller very similar to that of Figure 1 arranged in a stator body,

Figure 3 shows one embodiment of the invention with a cylindrical spinning impeller, a mixing section and a diffuser in a stator,

Figure 4 shows a second embodiment of the invention with a bladed spinning impeller as well as the optional addition of the mixing section of Figure 3,

Figure 5 shows a diagrammatic arrangement of the pump of Figures 3 and 4 which can have many applications,

Figure 6 illustrates a pump embodying the invention arranged for downhole pumping, and

Figure 7 illustrates an embodiment of the invention arranged to assist a conventional pump pumping multiphase fluids in which the gas phase is too large for the conventional pump on its own.

The spinning impellers shown in Figures 1 and 2 have a downstream end section 11 of approximately the shape of an oil drop and are mounted on an upstream hollow tube 12 which itself is supported for rotation in a bearing, not shown. A primary fluid 13 is supplied through the hollow tube 12 into the downstream section 11 from which it escapes through nozzles 14 which are directed generally in the downstream direction and each one is inclined to that direction at the same angle around the impeller so as to form jets which cause the impeller to rotate and also force a secondary medium 15 in the passage 16 surrounding the impeller in the downstream direction. The nozzles 14 in Figure 1 are hooded by hoods 17 whereas the one illustrated in Figure 2 appears to be a simple hole. Figure 2 shows the housing 18 surrounding the impeller, the housing being of constant cross-section in the region of the nozzles and downstream therefrom. The oil-drop shape of the impeller with its decreasing cross-section of the impeller downstream of the nozzles means that the passage for material being pumped increases in cross-section in the downstream direction.

The impeller 21 according to the illustrated embodiments shown in Figures 3 and 4 is of cylindrical shape and the nozzles 24 are arranged at the downstream region of the impeller. The impeller is mounted on an upstream hollow

fluid supply tube 22 for rotation together as described above. Downstream of the impeller is a non-rotating cylindrical axial stator body 25 of the same cross-section as the impeller 21. The housing 28 is of constant cross-section downstream of the region of the nozzles 24 and of the cylindrical body 25 so that the passage 23 for the materials being pumped is a constant section annulus. Downstream of the stationary body is a conical diffuser 26 axially aligned with the stator body so that the passage 27 for the materials at the region of the diffuser 26 increases in cross-section within the uniform bore of the housing 28. Upstream of the nozzles, the housing 28 is of greater cross-section 29 than the uniform bore and converges to the uniform bore immediately upstream of the nozzles. In the arrangement of Figure 4, blades 31 are mounted on the upstream portion of the spinning impeller, here at the start of the converging portion 32 of the housing, and are arranged to impart a swirl and an initial acceleration in the downstream direction to the media passing the impeller before the media reach the nozzles. The mechanical blades 31 upstream of the nozzles can be used in conjunction with or separately from the stationary cylindrical body 25 downstream of the rotating impeller and have been found to increase the efficiency of the pump.

The system can also include an additional driving force introduced by an auxiliary pump shown at 33 in Figure 4 to pressurise the driving fluid or by another rotary source such as the motor shown at 34 in Figure 3 which would drive the impeller at higher speeds than that which would be achieved by the effect of the nozzles alone. The components 33 and 34 are optional features

which can be applied alone or together to either embodiment. When the driving fluid is pressurised before entering the pump, the pressure of the mixture leaving the pump is increased. When the mixture leaving the pump is a multiphase (gas-liquid) product, the pressurising of the driving fluid avoids the possible need to use a multiphase pump downstream of the main pump. These systems would be more complex but for particular applications may be of benefit.

The pumps so described are suitable for many applications. Whereas many conventional pumps have flows which do not intermingle, the pumps of the present invention intermingle the driving and suction media flows to a high degree, enabling a good mixing and homogenisation of gas-liquid phases and liquid-liquid phases of fluids of different densities and viscosities.

Figure 5 shows the arrangement of the pump of Figures 3 and 4 in diagrammatic form. The pump of Figures 3 or 4 is indicated generally at 50 and receives primary (driving) fluid 13 and a secondary medium (suction fluid) 15. The output of the pump is a mixture 51 of the two inputs 13 and 15, and in its simplest arrangment the pump 50 acts as an in-line mixer. No mixing chamber apart from the annular chamber 23 is required.

Normally the pressures of the fluids 13, 15 are equal. If the primary fluid pressure P1 is greater than the suction fluid pressure P2, the mixture 51 will be at pressure P3, intermediate between P1 and P2; in this arrangement the pump 50 acts as an eductor, functioning like a jet pump with the additional advantage of being

able to handle gas liquid mixtures as the driving fluid as well as the suction fluid.

The secondary medium 15 can be of any phase or a mixture of phases and the primary fluid will act as a carrier fluid for the secondary medium, the pump 50 acting as a flow augmentor. If the secondary medium is an additive of any phase, the pump 50 acts as an inducer of additives, drawing the secondary medium from a container or (as in the case of sand on a submerged beach) from its natural environment. The secondary medium 15 could be a foaming agent, the pump 50 acting as a foam injector. The secondary medium 15 could be a chemical to be added to the main product which is the primary medium 13, for example, to dose the primary medium with an additive.

As illustrated in Figure 6, the pump 50 can operate as a downhole pump. A driving fluid 13 is in this case pumped from surface or at wellhead via a dedicated line 61 down the wellbore 62 where the main pump 50 will be located. The well fluids 55 flow via its suction line 28 to form the suction fluid 15. The mixture of the motive and the mixture fluid downstream of the main pump then flows upward through a conduit 56 in the well bore to wellhead.

The driving fluid 13 may also be mixed with free gas 57. The free gas when mixed with the well fluid will help to reduce the hydrostatic head of the mixture downstream of the main pump 50 in the well bore in a similar manner as is achieved by conventional gas lift operations.

Conventional pumps, even multiphase pumps, can only tolerate a maximum proportion of gas phase in the fluid being pumped. Such pumps can be used in a system having multiphase fluids with a proportion of gas phase greater than said maximum by providing a separator 59 upstream of the conventional pump and a pump 50 downstream of the conventional pump 60 as shown in Figure 7. The separator 59 separates out sufficient gas to bring the proportion of gas phase in the fluid supplied to the conventional pump 60 below said maximum, the separated gas phase being fed through a bypass conduit 61 and combined with the fluid downstream of the conventional pump 60 by means of the pump 50. The output of the pump 60 is the primary fluid and the separated gas phase the suction fluid of the pump 50. The conventional pump 60 may be a multiphase or a single phase pump.

CLAIMS

1. A pump comprising a housing (28), a hollow rotor (21) within the housing, means (22) for feeding driving fluid into the rotor interior, nozzles (24) on the rotor for forming jets of said driving fluid directed partly axially and partly tangentially into the chamber between the housing and the rotor,
characterised by a stator (25) downstream of the rotor forming with the housing an annular chamber (23) of uniform section along its length.

2. A pump as claimed in claim 1 wherein the stator (25) is of the same cross-section as the downstream end of the rotor (21).

3. A pump as claimed in claim 1 or claim 2 comprising a converging section stator portion (26) downstream of the portion (25) forming with the housing said annular chamber (23).

4. A pump as claimed in any one of claims 1 to 3 comprising blades (31) extending from the rotor (21) upstream of the nozzles (24) oriented to drive fluid axially and tangentially in the same sense as said jets.

5. A pump comprising a housing (28), a hollow rotor (21) within the housing, means (22) for feeding driving fluid into the rotor interior, nozzles (24) on the rotor for forming jets of said driving fluid directed partly axially and partly tangentially into the chamber between the housing and the rotor,

characterised by blades (31) extending from the rotor (21) upsteam of the nozzles (24) oriented to drive the fluid axially and tangentially in the same sense as the jets.

6. A pump as claimed in any one of claims 1 to 5 comprising means (34) mechanically connected to the rotor for rotating said rotor.

7. A pump as claimed in any one of claims 1 to 6 wherein said driving fluid feeding means (22) is connected to means (33) for feeding said driving fluid under pressure.

8. An in-line mixer for two fluids comprising a pump (50) as claimed in claim 1 and means (29) for supplying one said fluid to said housing (28) on the exterior of said rotor, said driving fluid feeding means (22) being connected to a source (56) of the other said fluid.

9. An eductor for first and second fluids at different pressures comprising a pump (50) as claimed in claim 1 and means (29) for supplying the fluid of lower pressure to said housing (28) on the exterior of said rotor (21), said driving fluid feeding means (22) being connected to a source (56) of the fluid of higher pressure.

10. A downhole pump assembly comprising a pump (50) as claimed in claim 1, said driving fluid feeding means (22) being connected to a source (34) of pressurised driving fluid, the interior of the housing on the exterior of the rotor being connected to fluids (55) in

the hole and means (56) to convey the fluids downstream of the pump up the hole.

11. A pump assembly as claimed in claim 10 comprising means to introduce free gas into the driving fluid.

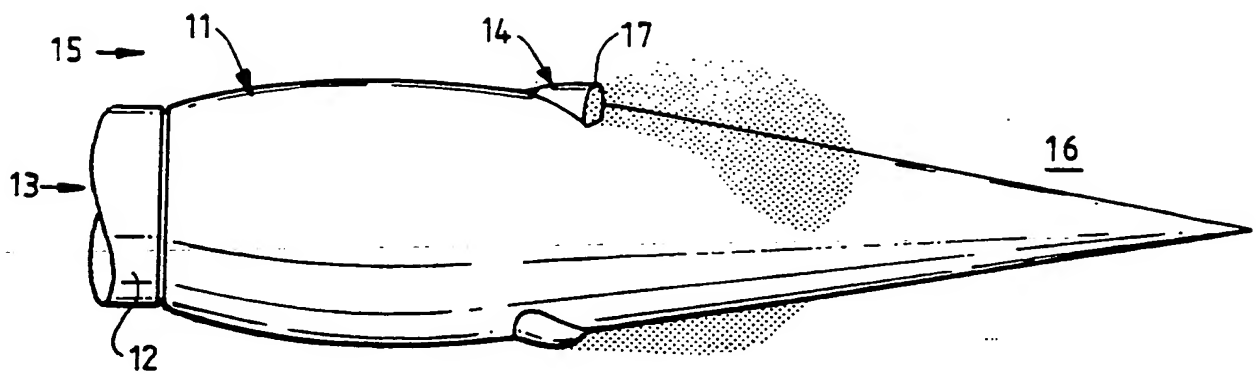


FIG.1

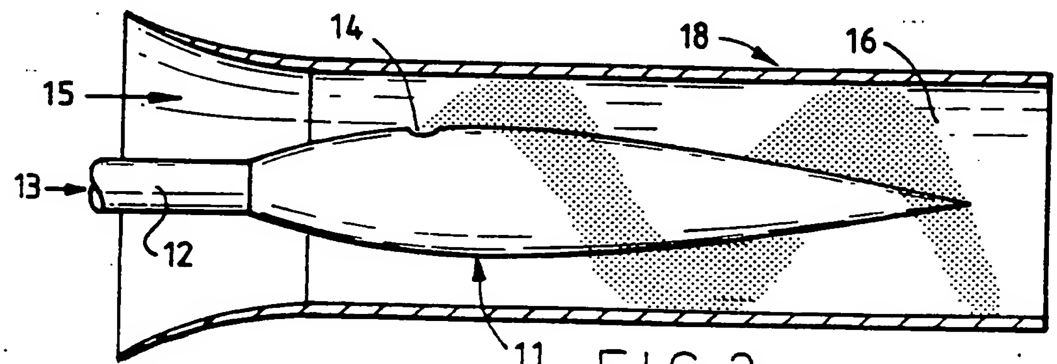


FIG.2

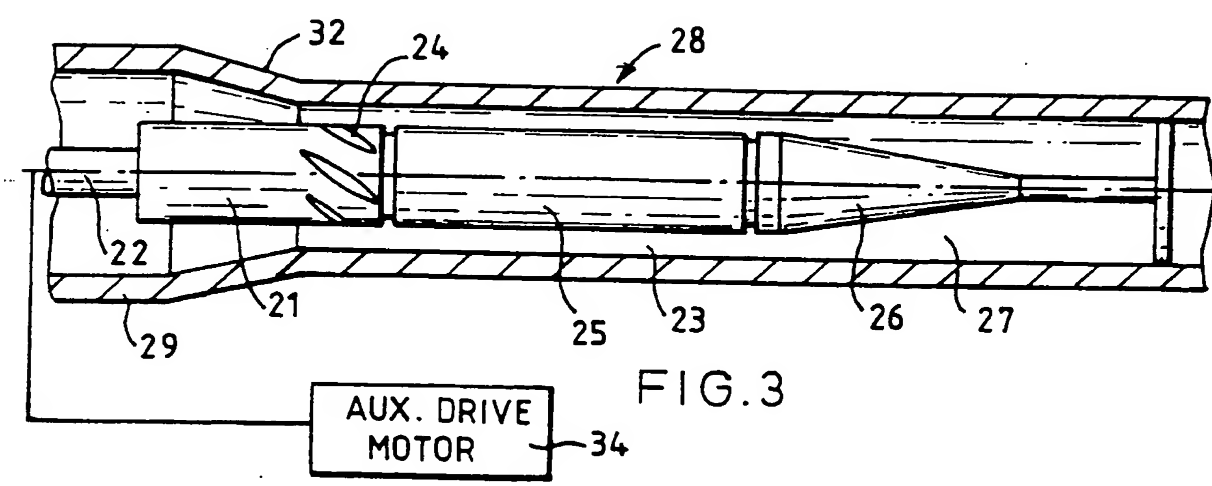
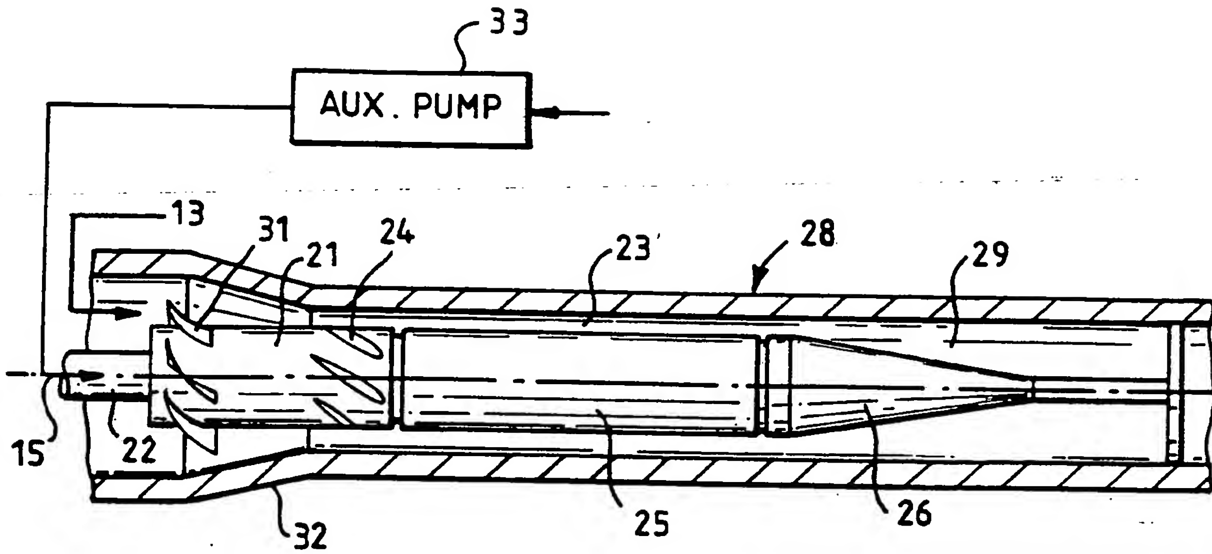


FIG.3


33
AUX. PUMP
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31
21
24
23
28
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15
22
32
25
26

FIG. 4

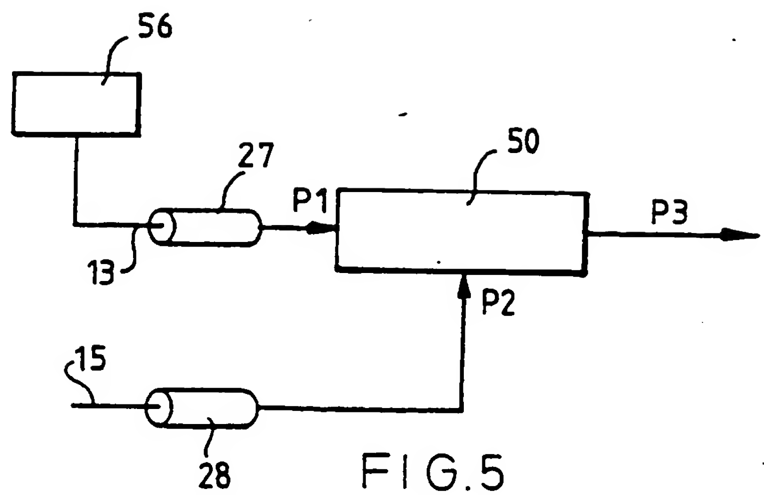
56
27
50
P1
P3
13
P2
15
28

FIG.5

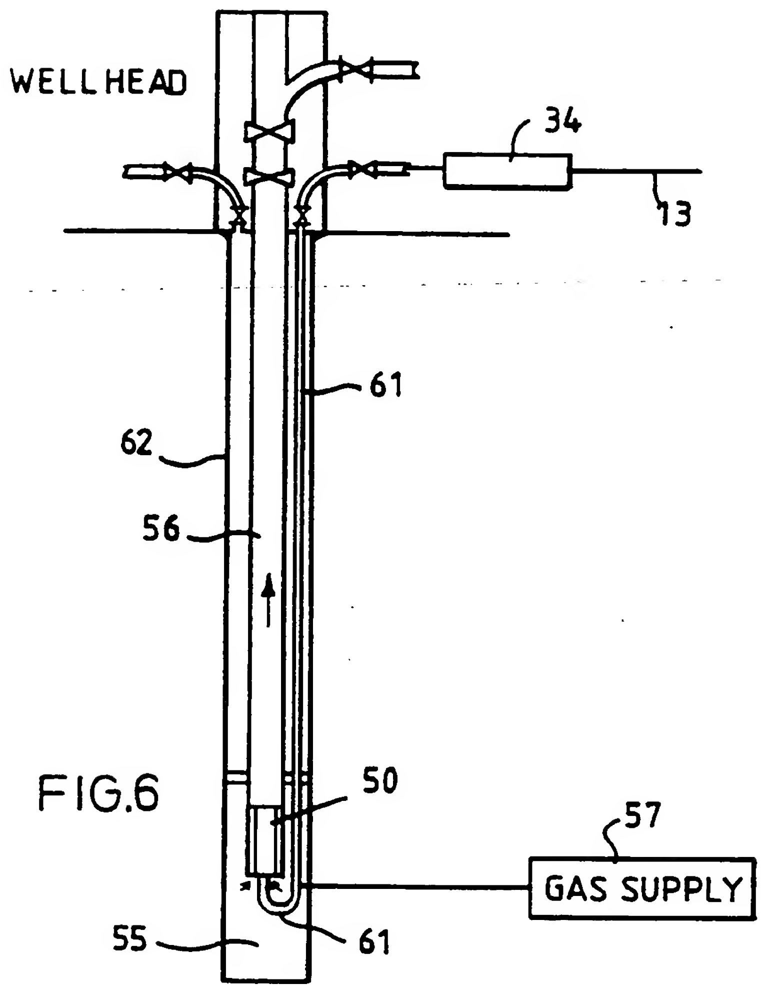

FIG.6

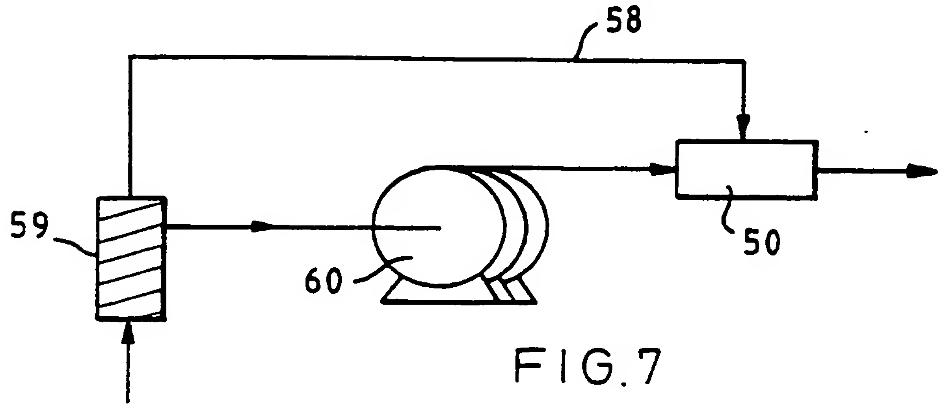

FIG.7

PCT/GB 92/01811

INTERNATIONAL SEARCH REPORT

International Application

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 F04D13/04; F04D31/00; F04D13/10; F04D3/00
F04D17/18; E21B43/12; F04D29/54

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl. 5	F04D ; E21B

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category °	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No.[13]
A	GB,A,733 544 (HENNING GUNTHER BARTELS) 13 May 1955 see page 1, line 9 - line 15 see page 2, line 12 - line 43 see page 2, line 97 - line 110; figures 1,4 ---	1-3,5
A	GB,A,860 073 (RENSSELAER POLYTECHNIC) 1 February 1961 cited in the application see page 1, line 10 - line 23 see page 10, line 29 - page 11, line 43; figures 5,6,7,8 ---	1,5
A	DE,A,1 528 702 (FREIHERR VON FALKENHAUSEN) 4 June 1969 see page 1, line 16 - page 3, line 6; figure ---	1,5-7

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° Special categories of cited documents : [10]

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
13 NOVEMBER 1992	08. 12. 92
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	ZIDI K.

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III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)		
Category °	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
A	US,A,3 304 006 (ADAMS) 14 February 1967 see column 1, line 39 - line 42 see column 1, line 72 - column 2, line 25 see column 9, line 27 - line 50; figures 8-10	1,5
A	GB,A,1 448 167 (KOBE) 2 September 1976 see page 1, line 11 - line 27 see page 2, line 9 - line 118; figures 1,2	10

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. GB 9201811 SA 65148

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 13/11/92
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB-A-733544		None	
GB-A-860073		None	
DE-A-1528702	04-06-69	None	
US-A-3304006		None	
GB-A-1448167	02-09-76	None	

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